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Nagato et al.

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(54) **INTERFERENCE FILTER, DISPLAY DEVICE,
AND DISPLAY DEVICE MANUFACTURING
METHOD**

USPC 359/580–590, 577, 578, 579, 260, 261;
356/454, 505, 506, 519; 353/20
See application file for complete search history.

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G02F 1/1362 (2006.01)

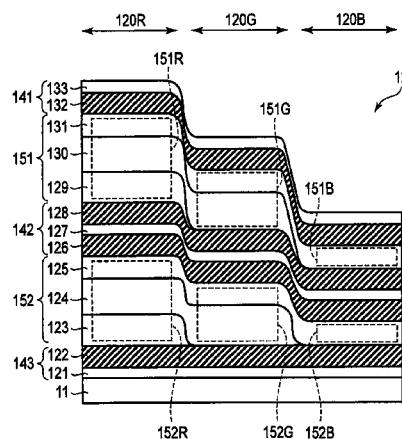
(52) **U.S. Cl.**
CPC **G02B 5/284** (2013.01); **G02F 1/133514**
(2013.01); **G02F 2001/133521** (2013.01); **G02F**
2001/136222 (2013.01)

(58) **Field of Classification Search**
CPC G02B 5/284; G02F 2001/136222;
G02F 2001/133521; G02F 1/133514

ABSTRACT

According to one embodiment, a display device includes an interference filter including following layers, and a display layer. The first common layer includes first and second regions. The second common layer faces the first common layer. The first spacer layer is provided between the first and second common layers and includes first and second portions facing the first and second regions. The thickness of the first portion is different from the thickness of the second portion. The second spacer layer faces at least one of the first and second portions through the second common layer and is made of the same material as that of the first spacer layer. The coating layer faces the second common layer through the second spacer layer.

15 Claims, 13 Drawing Sheets



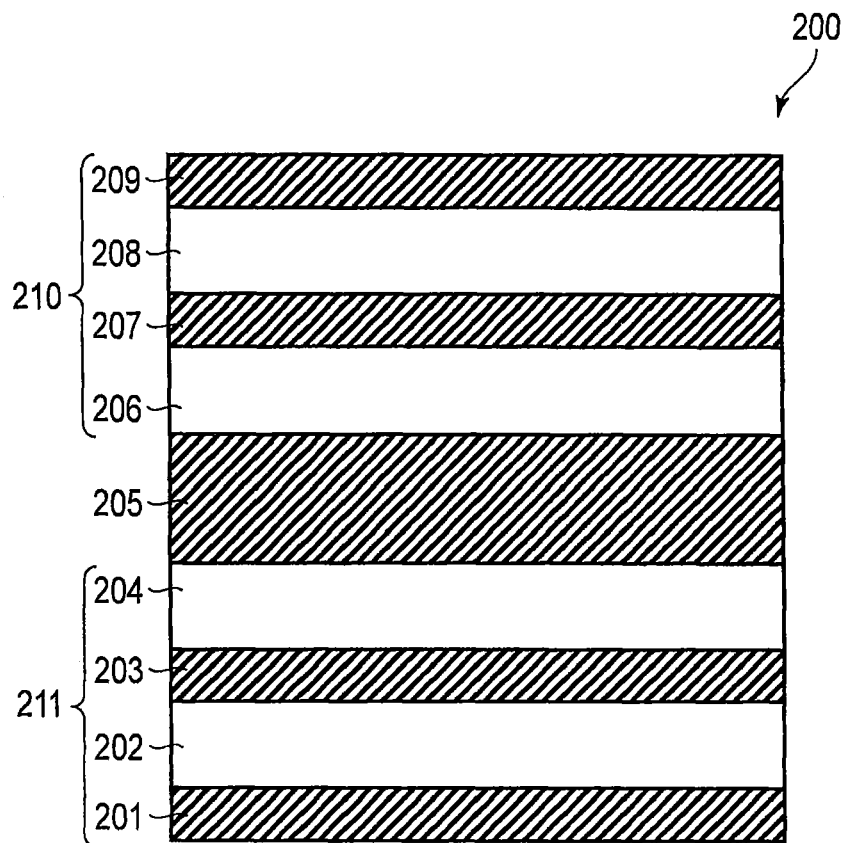


FIG. 1
REFERENCE
FIGURE

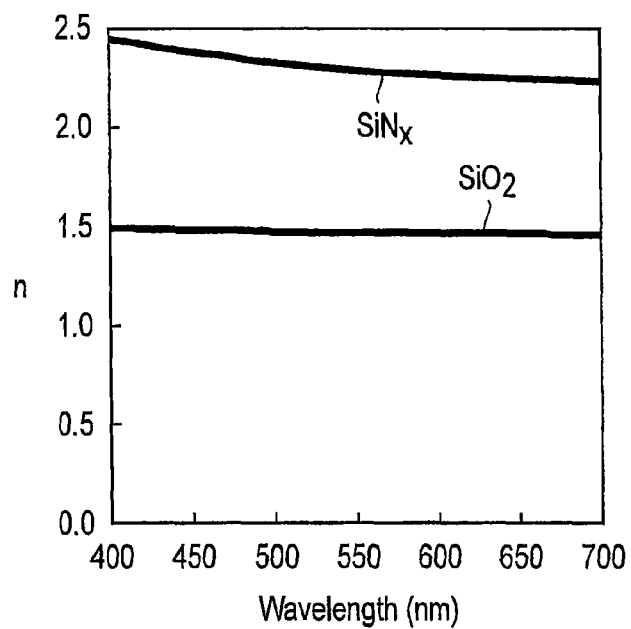


FIG. 2A
REFERENCE
FIGURE

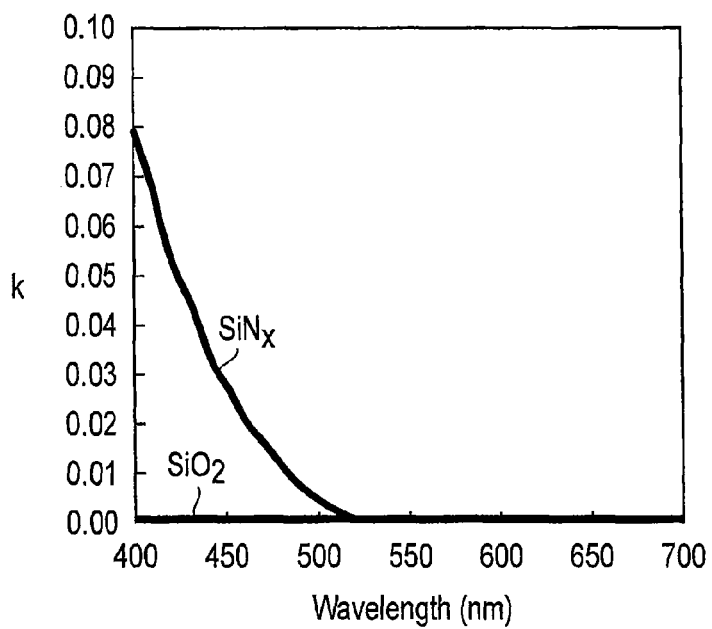


FIG. 2B
REFERENCE
FIGURE

200

		200R(nm)	200G(nm)	200B(nm)
210	209	SiN _x	61.4	61.4
	208	SiO ₂	91.0	91.0
	207	SiN _x	61.4	61.4
	206	SiO ₂	91.0	91.0
205	205	SiN _x	35.0	128.4
211	204	SiO ₂	91.0	91.0
	203	SiN _x	61.4	61.4
	202	SiO ₂	91.0	91.0
	201	SiN _x	61.4	61.4

FIG. 3A
REFERENCE
FIGURE

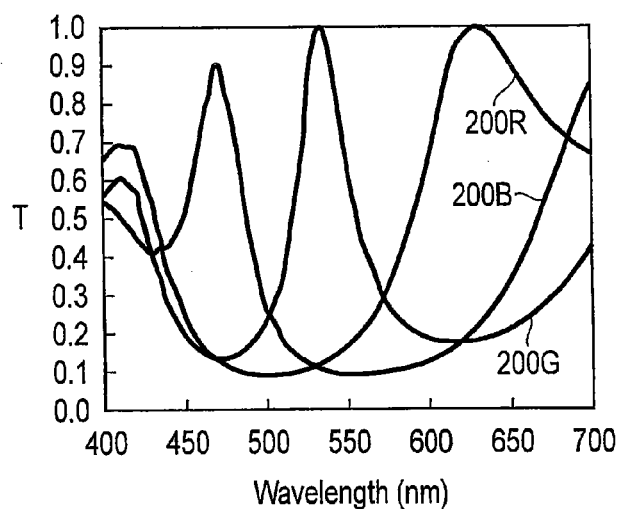


FIG. 3B
REFERENCE
FIGURE

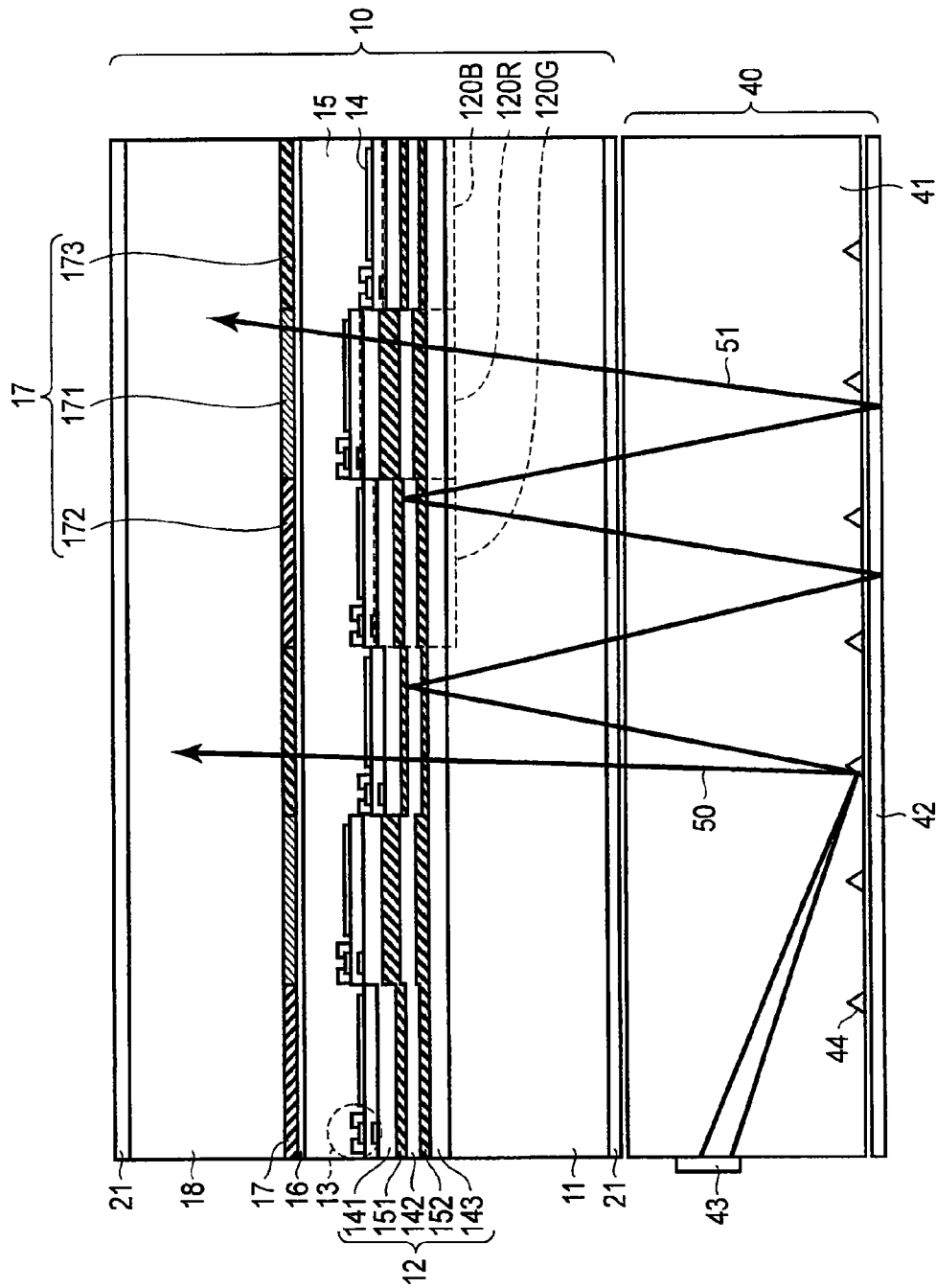


FIG. 4

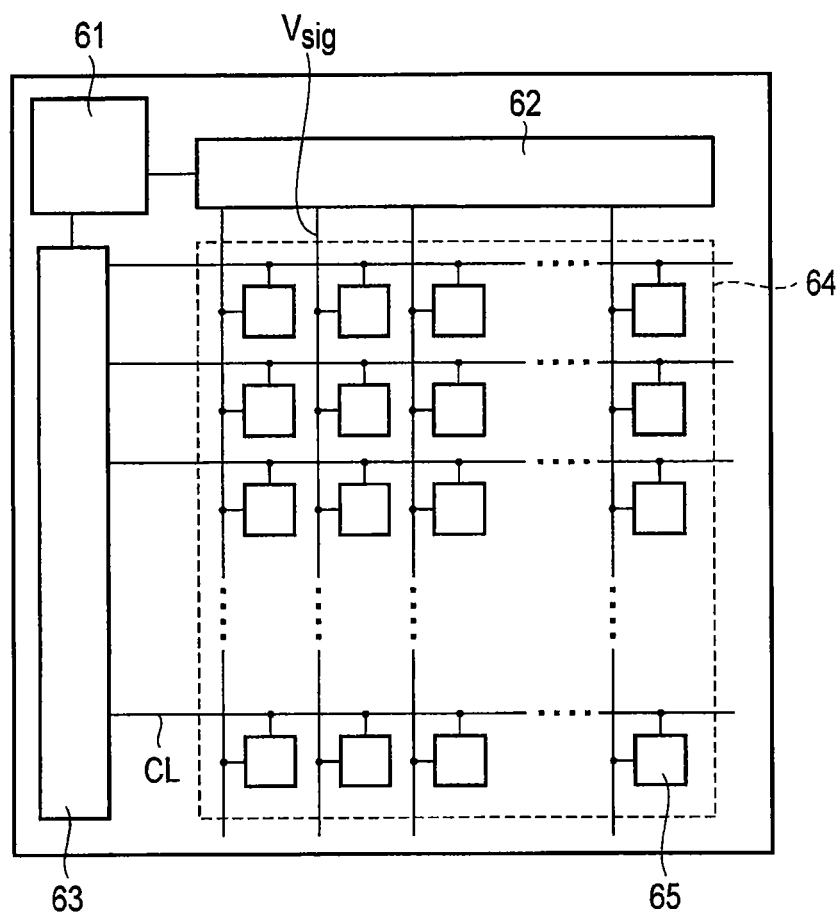


FIG. 5

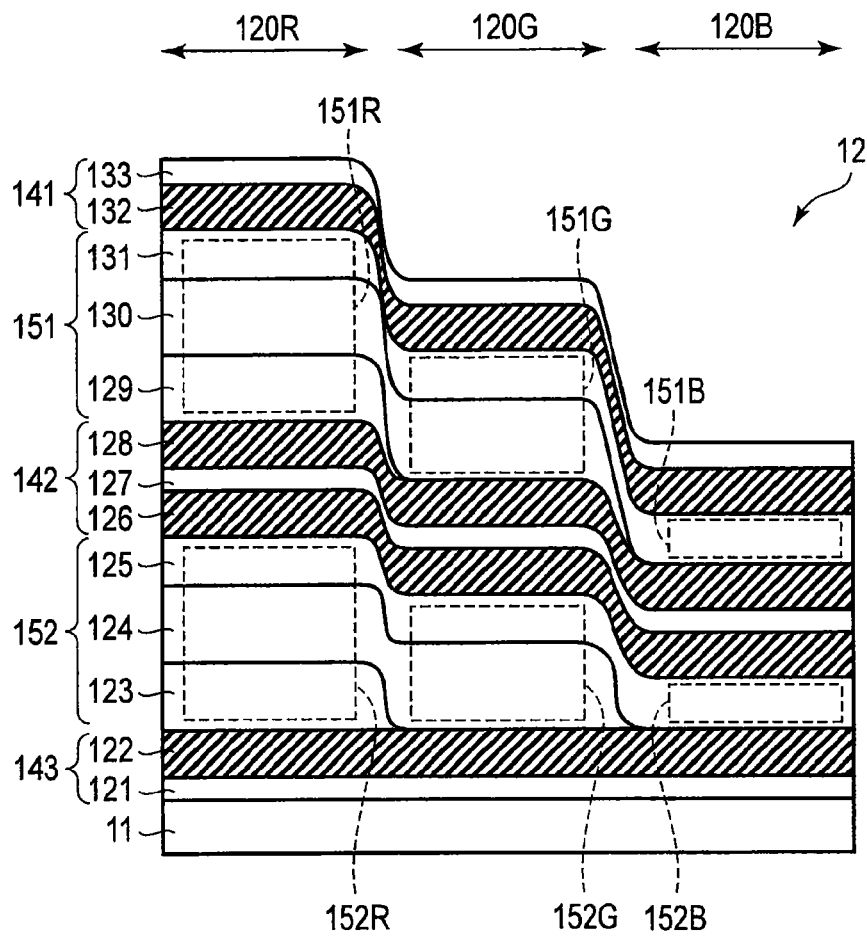


FIG. 6A

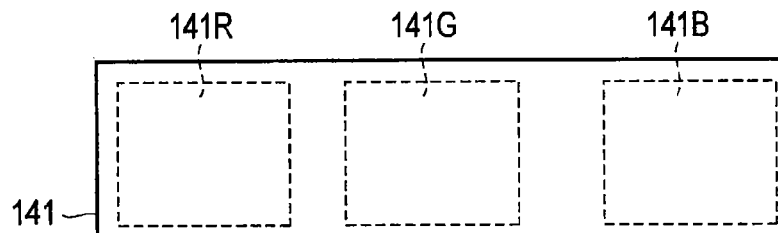


FIG. 6B

		120R(nm)	120G(nm)	120B(nm)
141	133	SiO ₂	91.6	91.6
	132	SiN _x	58.15	58.15
151(129~131)		SiO ₂	250.0 (151R)	180.0 (151G)
142	128	SiN _x	58.15	58.15
	127	SiO ₂	91.6	91.6
	126	SiN _x	58.15	58.15
152(123~125)		SiO ₂	250.0 (152R)	180.0 (152G)
143	122	SiN _x	58.15	58.15
	121	SiO ₂	91.6	91.6

FIG. 7A

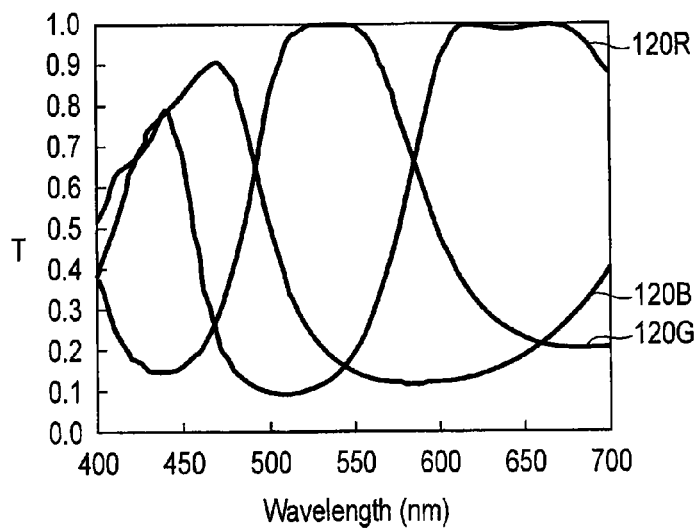


FIG. 7B

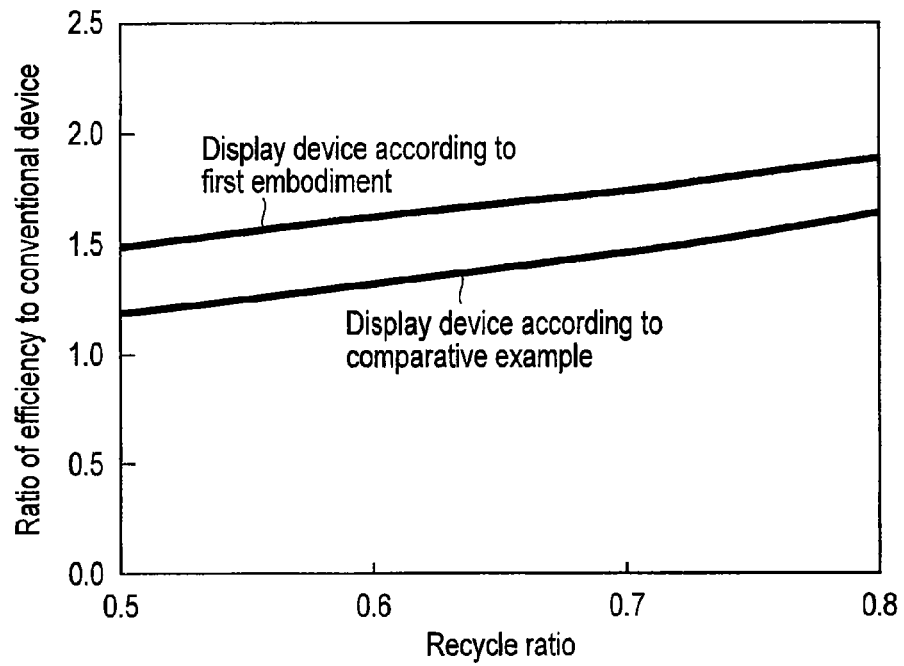


FIG. 8

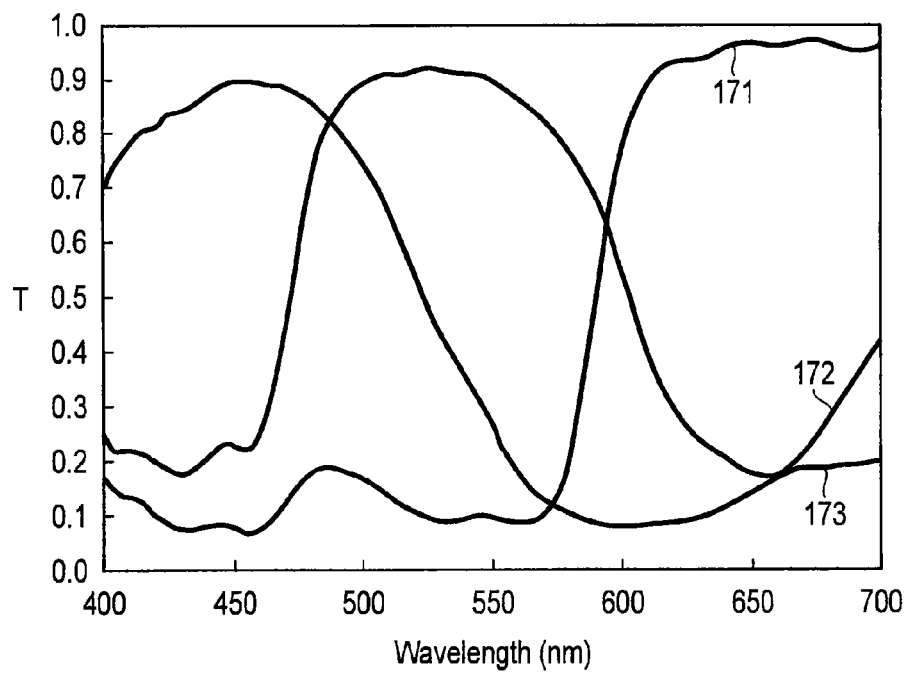


FIG. 9

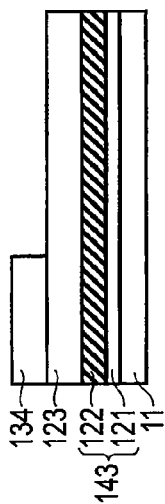


FIG. 10B

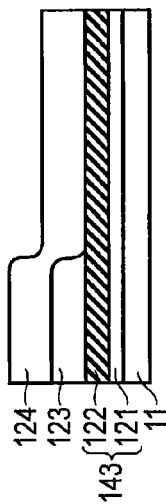


FIG. 10D

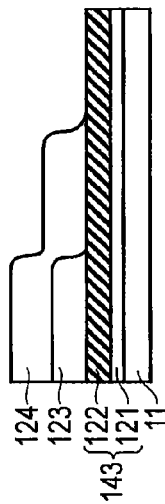


FIG. 10F

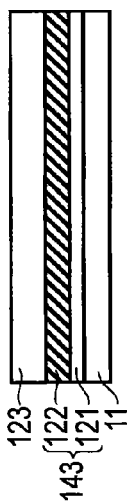


FIG. 10A

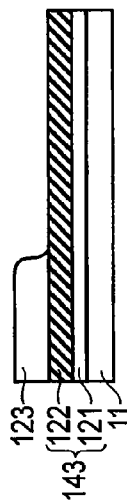


FIG. 10C

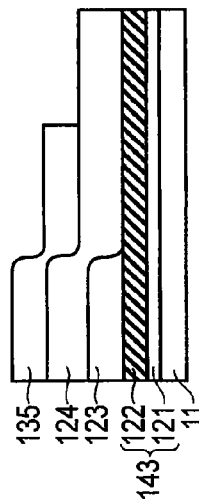


FIG. 10E

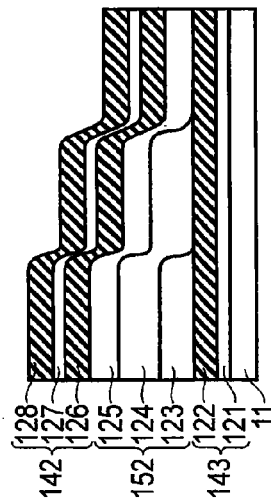


FIG. 10G

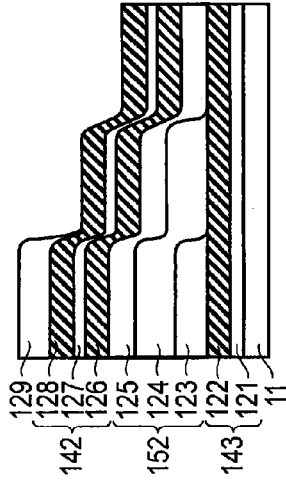


FIG. 11B

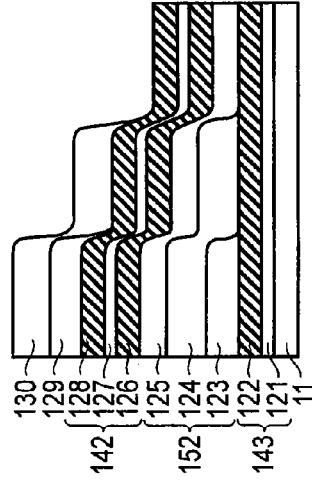


FIG. 11D

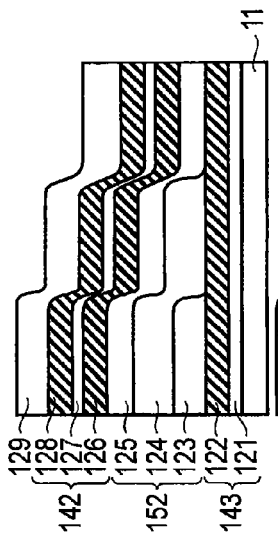


FIG. 11A

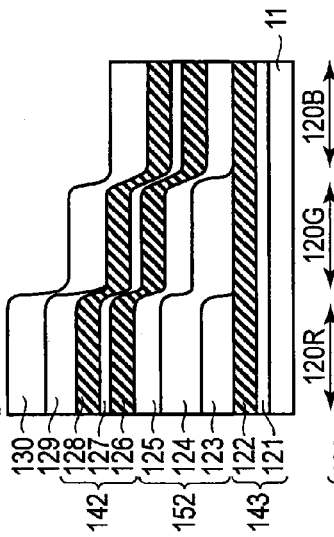


FIG. 11C

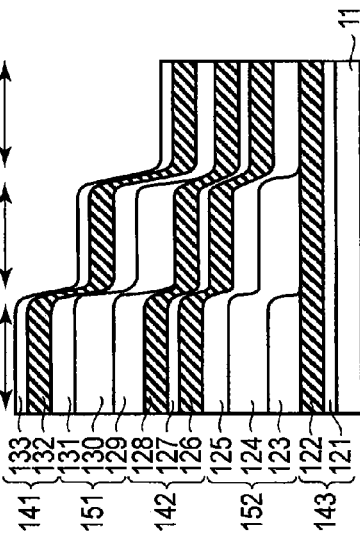


FIG. 11E

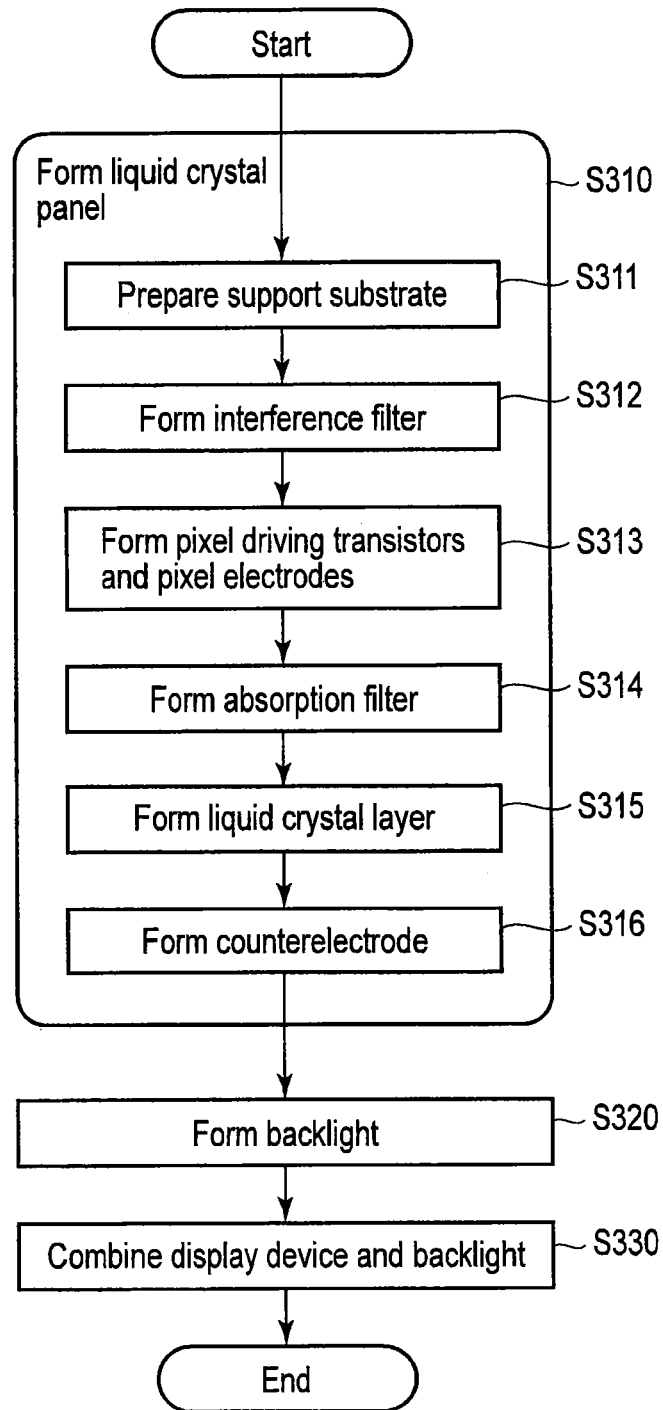


FIG. 12

121

		121B(nm)	121G(nm)	121R(nm)
141	169	SiO ₂	73.0	73.0
	168	SiN _x	51.4	51.4
	167	SiO ₂	73.0	73.0
	151	SiN _x	99.1 (151B)	133.9 (151G)
142	166	SiO ₂	85.0	85.0
	165	SiN _x	63.4	63.4
	164	SiO ₂	85.0	85.0
	163	SiN _x	63.4	63.4
	152	SiN _x	0.0	72.5
143	162	SiO ₂	0.0	89.0
	161	SiN _x	0.0	37.4

FIG. 13A

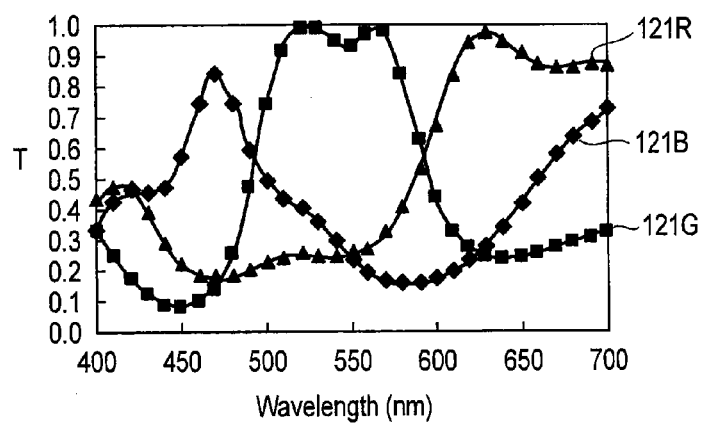


FIG. 13B

122

		122B(nm)	122G(nm)	122R(nm)	
143	180	SiO ₂	0.0	89.0	0.0
	179	SiN _x	0.0	53.4	0.0
	178	SiO ₂	0.0	89.0	0.0
	152	SiN _x	0.0	67.6	0.0
142	177	SiN _x	59.4	59.4	59.4
	176	SiO ₂	89.0	89.0	89.0
	175	SiN _x	59.4	59.4	59.4
	174	SiO ₂	89.0	89.0	89.0
	151	SiN _x	89.1 (151B)	127.0 (151G)	32.8 (151R)
141	173	SiO ₂	93.0	93.0	93.0
	172	SiN _x	55.4	55.4	55.4
	171	SiO ₂	93.0	93.0	93.0

FIG. 14A

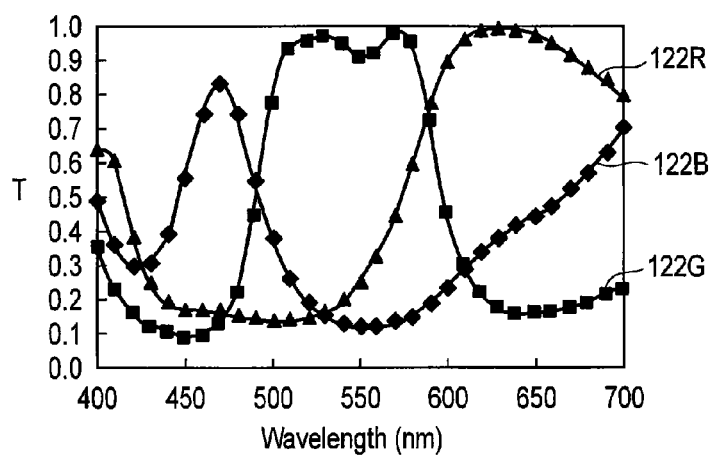


FIG. 14B

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INTERFERENCE FILTER, DISPLAY DEVICE, AND DISPLAY DEVICE MANUFACTURING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2012-199809, filed Sep. 11, 2012, the entire contents of which are incorporated herein by reference.

FIELD

Embodiments described herein relate generally to an interference filter, a display device, and a display device manufacturing method.

BACKGROUND

The demand for display devices represented by a liquid crystal display, a plasma display, and an organic EL display is even more increasing as the digital terrestrial broadcasting has started, and the Internet and mobile phones have become popular. A color filter is arranged in such a display device. Color display is performed by red, green, and blue light components that have passed through the color filter. In general, a light absorption (absorption) color filter using pigments or dyes is used as the color filter. An absorption color filter transmits light in a specific wavelength region and absorbs light in other wavelength regions. For example, when white light enters a blue color filter, blue light components pass through the color filter, and green and red light components are absorbed by the color filter. This also applies to green and red color filters. Since the color filters absorb light, a loss of light occurs.

There is proposed a display device using an interference color filter in place of the absorption color filter. The interference color filter reflects light in wavelength regions other than a transmission wavelength region.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view showing an interference filter according to a comparative example;

FIGS. 2A and 2B are views showing the characteristics of silicon nitride (SiN_x) and silicon oxide (SiO_2);

FIG. 3A is a view showing an example of the interference filter according to the comparative example;

FIG. 3B is a view showing the light transmission characteristic of the interference filter shown in FIG. 3A;

FIG. 4 is a sectional view showing a display device according to the first embodiment;

FIG. 5 is a plan view showing the display device according to the first embodiment;

FIG. 6A is a sectional view showing an interference filter according to the first embodiment;

FIG. 6B is a plan view showing the interference filter according to the first embodiment;

FIG. 7A is a view showing an example of the interference filter according to the first embodiment;

FIG. 7B is a view showing the light transmission characteristic of the interference filter shown in FIG. 7A;

FIG. 8 is a view showing the characteristics of the display device according to the first embodiment and the display device according to the comparative example;

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FIG. 9 is a view showing an example of the light transmission characteristic of an absorption filter according to the first embodiment;

FIGS. 10A, 10B, 10C, 10D, 10E, 10F, 10G, 11A, 11B, 11C, 11D, and 11E are sectional views showing a method of manufacturing the interference filter of the display device according to the first embodiment;

FIG. 12 is a flowchart showing a method of manufacturing the display device according to the first embodiment;

FIG. 13A is a view showing an example of an interference filter according to the second embodiment;

FIG. 13B is a view showing the light transmission characteristic of the interference filter shown in FIG. 13;

FIG. 14A is a view showing an example of an interference filter according to the third embodiment; and

FIG. 14B is a view showing the light transmission characteristic of the interference filter shown in FIG. 14A.

DETAILED DESCRIPTION

In general, according to one embodiment, a display device includes an interference filter and a display layer facing the interference filter. The interference filter includes a first common layer, a second common layer, a first spacer layer, a second spacer layer, and a coating layer. The first common layer includes a first region and a second region. The second common layer faces the first common layer. The first spacer layer is provided between the first common layer and the second common layer and includes a first portion facing the first region and a second portion facing the second region. The first portion has a first thickness, and the second portion has a second thickness different from the first thickness. The second spacer layer faces at least one of the first portion and the second portion of the first spacer layer through the second common layer and is made of a same material as a material of the first spacer layer. The coating layer faces the second common layer through the second spacer layer. Each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film.

According to another embodiment, an interference filter includes a first common layer, a second common layer, a first spacer layer, a second spacer layer, and a coating layer. The first common layer includes a first region and a second region. The second common layer faces the first common layer. The first spacer layer is provided between the first common layer and the second common layer and includes a first portion facing the first region and a second portion facing the second region. The first portion has a first thickness, and the second portion has a second thickness different from the first thickness. The second spacer layer faces at least one of the first portion and the second portion of the first spacer layer through the second common layer and is made of a same material as a material of the first spacer layer. The coating layer faces the second common layer through the second spacer layer. Each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film.

According to another embodiment, there is provided a display device manufacturing method including forming an interference filter, and forming a display layer facing the interference filter. The interference filter includes a first common layer, a second common layer, a first spacer layer, a second spacer layer, and a coating layer. The first common layer includes a first region and a second region. The second common layer faces the first common layer. The first spacer layer is provided between the first common layer and the

second common layer and includes a first portion facing the first region and a second portion facing the second region. The first portion has a first thickness, and the second portion has a second thickness different from the first thickness. The second spacer layer faces at least one of the first portion and the second portion of the first spacer layer through the second common layer and is made of a same material as a material of the first spacer layer. The coating layer faces the second common layer through the second spacer layer. Each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film.

Hereinafter, various embodiments will be described in detail with reference to the accompanying drawings.

Note that the drawings are merely schematic and conceptual, and the relationship between the thickness and the width of each portion, the dimension ratio between the portions, and the like are not necessarily the same as in reality. In addition, the dimension or ratio may change between the drawings even for identical portions.

Note that the same reference numerals denote elements that are the same as those described concerning already mentioned drawings throughout the specification and drawings, and a detailed description thereof will be omitted appropriately.

A Fabry-Perot interference filter (interference color filter) is formed by stacking two or more kinds of dielectric films having different refractive indices. The wavelength region (transmission region) of light that passes through the Fabry-Perot interference filter is determined by the materials and thicknesses of the dielectric film and the number of stacked dielectric films. To manufacture an ideal interference filter having little loss of light, which transmits light in the transmission region almost 100% and reflects light in other wavelength regions (reflection regions) almost 100% upon receiving white light, dozens of dielectric films need to be stacked. Since the manufacturing process becomes very complex, manufacturing takes long time, and the production cost increases. This makes it difficult to mount the interference filter on inexpensive consumer appliances.

Before the description of the embodiments, an interference filter according to a comparative example will be explained. FIG. 1 is a sectional view showing an interference filter 200 according to a comparative example. The interference filter 200 includes nine dielectric films. More specifically, the interference filter 200 includes five silicon nitride films (SiN_x) 201, 203, 205, 207, and 209, and four silicon oxide films (SiO_2) 202, 204, 206, and 208 provided between the silicon nitride films. Out of the nine films, the four films on the upper side will be referred to as a first common layer 210, and the four films on the lower side will be referred to as a second common layer 211. The silicon nitride film 205 interposed between the first common layer 210 and the second common layer 211 will be referred to as a spacer layer. Changing the thickness of each layer enables to change the transmission region of the interference filter 200. For example, when the thickness of the spacer layer 205 is changed without changing the thicknesses of the first common layer 210 and the second common layer 211, the interference filter 200 can change the transmission region so as to transmit red light, green light, or blue light.

FIGS. 2A and 2B are graphs showing the optical characteristics of silicon nitride (SiN_x) and silicon oxide (SiO_2) used in the above-described comparative example and the embodiments to be described below. In FIG. 2A, the transverse axis represents the wavelength (unit: nm), and the vertical axis represents a refractive index n . In FIG. 2B, the transverse axis

represents the wavelength (unit: nm), and the vertical axis represents an extinction coefficient k . As the silicon nitride film, a silicon nitride film whose refractive index near a wavelength of 550 nm is adjusted to 2.3 is used.

FIG. 3A is a table showing an example of the interference filter according to the comparative example, and shows the thicknesses (unit: nm) of nine films that form each of an interference filter (red interference filter) 200R that transmits red light, an interference filter (green interference filter) 200G that transmits green light, and an interference filter (blue interference filter) 200B that transmits blue light. For example, the red interference filter 200R is formed by stacking the 61.4-nm-thick silicon nitride film 201, the 91.0-nm-thick silicon oxide film 202, the 61.4-nm-thick silicon nitride film 203, the 91.0-nm-thick silicon oxide film 204, the 35.0-nm-thick silicon nitride film 205, the 91.0-nm-thick silicon oxide film 206, the 61.4-nm-thick silicon nitride film 207, the 91.0-nm-thick silicon oxide film 208, and the 61.4-nm-thick silicon nitride film 209 sequentially from the lower side. The green interference filter 200G is the same as the red interference filter 200R except that the thickness of the silicon nitride film 205 serving as a spacer layer is 128.4 nm. The blue interference filter 200B is the same as the red interference filter 200R except that the thickness of the silicon nitride film 205 serving as a spacer layer is 82.2 nm.

FIG. 3B is a graph showing the light transmission characteristics of interference filters 200R, 200G, and 200B shown in FIG. 3A. The transverse axis represents the wavelength (unit: nm) of light that passes through the interference filter, and the vertical axis represents a transmittance T . Because of the small number of stacked layers, the interference filter according to the comparative example is inexpensive and easy to manufacture, although the spectrum of the transmission region is narrow. In addition, since the transmittances of light components having wavelengths near, for example, 500 and 570 nm are low in all interference filters 200R, 200G, and 200B. When a color filter is formed using interference filters 200R, 200G, and 200B, the transmittances of light components are low near 500 and 570 nm in this color filter. That is, these light components are reflected by the interference filters and are hardly output from the display device. Hence, the light components are not used for display, resulting in a loss of light.

The interference filter ideally has a transmittance of zero in wavelength regions other than the transmission region. In interference filters 200R, 200G, and 200B, however, the transmittance is high in wavelength regions other than the transmission region. Hence, for example, light that passes through the green interference filter 200G includes light components of colors other than green. This leads to a decrease in the purity of the display color of the display device and a decrease in the color gamut.

The embodiments will be described below.

First Embodiment

A display device according to the first embodiment will be described. As the display device, a liquid crystal display will be exemplified. FIG. 4 is a sectional view showing the display device according to the first embodiment.

A display device includes a liquid crystal panel 10 and a backlight 40. The liquid crystal panel 10 includes a support substrate 11, an interference filter 12 provided on the support substrate 11, display circuits such as pixel driving transistors 13 and pixel electrodes 14 provided on the interference filter 12, a liquid crystal layer 15 that is a display layer provided on the display circuits and the pixel electrodes 14, a counterelec-

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trode **16** provided on the liquid crystal layer **15**, an absorption filter **17** provided on the counterelectrode **16**, and a counter-substrate **18** provided on the absorption filter **17**. A polarizing layer **21** is provided on a surface of each of the support substrate **11** and the countersubstrate **18** on a side not opposite to the liquid crystal layer **15**.

The interference filter **12** includes a red interference filter (also called a first interference filter portion) **120R**, a green interference filter (also called a second interference filter portion) **120G**, and a blue interference filter (also called a third interference filter portion) **120B**. The red interference filter **120R** transmits light in the red wavelength region (first wavelength region) and reflects light in other wavelength regions including green and blue. The green interference filter **120G** transmits light in the green wavelength region (second wavelength region) and reflects light in other wavelength regions including red and blue. The blue interference filter **120B** transmits light in the blue wavelength region (third wavelength region) and reflects light in other wavelength regions including red and green. The red interference filter **120R**, the green interference filter **120G**, and the blue interference filter **120B** are formed by stacking a plurality of dielectric films having different refractive indices. A detailed structure of the interference filter **12** will be described later.

Note that a wavelength region of light that passes through the interference filter indicates a wavelength region of a transmittance higher than those of other wavelength regions. A wavelength region of light that is reflected by the interference filter indicates a wavelength region of a reflectance higher (a transmittance lower) than those of other wavelength regions. For example, a wavelength region corresponding to the half width of the transmission spectrum of the interference filter can be the wavelength region of light that passes through the interference filter.

The absorption filter **17** includes a red absorption filter **171**, a green absorption filter **172**, and a blue absorption filter **173**. One of the color absorption filters **171**, **172**, and **173** is provided in correspondence with each pixel. The red absorption filter **171** faces the red interference filter. The green absorption filter **172** faces the green interference filter. The blue absorption filter **173** faces the blue interference filter. The absorption filter **17** faces the interference filter **12** through the liquid crystal layer **15**.

One pixel driving transistor **13** and one pixel electrode **14** are provided for each pixel. In addition, one kind of interference filter **12** and one kind of absorption filter are provided for each pixel. Although not illustrated, signal lines and scan lines are formed on the interference filter **12** as the display circuits. The pixel driving transistor **13** controls a voltage applied between the pixel electrode **14** and the counterelectrode **16**.

When a voltage is applied between the pixel electrode **14** and the counterelectrode **16**, the orientation of liquid crystal of the liquid crystal layer **15** provided between them changes so as to pass light or not. The liquid crystal panel **10** can thus perform image display by passing light from the backlight **40** or not for each pixel.

The support substrate **11** and the countersubstrate **18** are made of an optically transparent material such as glass or a transparent resin.

The interference filter **12** is a filter that transmits light in a specific wavelength region and reflects light in other wavelength regions. The interference filter **12** is formed from a plurality of dielectric films having different refractive indices. For example, the interference filter **12** is formed by alternately stacking layers of a high-refractive-index material and layers of a low-refractive-index material. Representative

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high-refractive-index dielectric materials are TiO_2 , Ta_2O_5 , ZnO_2 , ZnS , ZrO_2 , CeO_2 , Sb_2S_3 , and the like. Representative low-refractive-index dielectric materials are SiO_2 , MgF_2 , Na_3AlF_6 , and the like.

As the pixel driving transistor **13**, for example, a bottom gate type or top gate type thin film transistor is used. In one example, one pixel driving transistor **13** is arranged for each pixel.

The pixel electrodes **14** and the counterelectrode **16** are made of an optically transparent conductive material such as indium tin oxide.

The absorption filter **17** is a filter that transmits light in a specific wavelength region and absorbs light in other wavelength regions. The absorption filter **17** is formed using, for example, pigments or dyes.

The liquid crystal layer **15** is made of a material that changes the light transmittance between a state in which an electric field is applied and a state in which no electric field is applied. The polarizing layer **21** is formed from a polarizing film for polarizing light that has entered the liquid crystal layer **15** and light that has passed through the liquid crystal layer **15**.

The backlight **40** includes a reflecting portion **42** facing the support substrate **11**, a light guide portion **41** provided between the support substrate **11** and the reflecting portion **42**, and a light source **43** provided on the side surface of the light guide portion **41**. The light guide portion **41** has concave portions **44** on a side (bottom surface) facing the reflecting portion **42**.

The light guide portion **41** is made of an optically transparent material such as an acrylic resin. As the light source **43**, for example, an LED is used. The reflecting portion **42** is made of a material having a high light reflectance, for example, a metal such as aluminum. The concave portion **44** need only have at least one inclined surface with respect to the surface of the light guide portion **41** facing the reflecting portion **42**, and can have, for example, a pyramidal shape or a ridge shape with a triangular section.

Light emitted by the light source **43** enters the light guide portion **41** and propagates through the light guide portion **41** while being totally reflected. At this time, when the light strikes the concave portion **44**, the total reflection condition is broken down by the concave portion **44**, and the light is reflected to the upper surface where the liquid crystal panel **10** is located. The reflected light exits from the light guide portion **41**, passes through the support substrate **11**, and enters the interference filter **12**. Out of the light that has entered the interference filter **12**, a light component in the transmission region of the interference filter passes through the interference filter **12** and then through the liquid crystal layer **15** and the absorption filter **17**, and exits out of the liquid crystal panel **10**, as indicated by a light beam **50**.

On the other hand, out of the light that have entered the interference filter **12**, almost all light components outside the transmission region of the interference filter are reflected and returned to the side of the backlight **40**. For example, a light beam **51** indicates an example of a red light component. This light component propagates through the light guide portion **41** while being continuously totally reflected by the bottom surface of the light guide portion **41** and the green or blue interference filter. Upon reaching the red interference filter **120R**, the light component passes through the red interference filter **120R** and then through the liquid crystal layer **15** and the absorption filter **17**, and exits out of the liquid crystal panel **10**.

As described above, the interference filter **12** absorbs light little as compared to the absorption filter **17**. For this reason,

almost all light components from the backlight 40 can pass through the interference filters 12 of all colors, and little loss of light occurs.

FIG. 5 is a plan view showing the display device according to the first embodiment.

The display device includes a display region 64 in which a plurality of pixel portions 65 are provided in a matrix, and a signal line driving circuit 62, a control line driving circuit 63, and a controller 61 which are provided around the display region 64. The controller 61 is connected to the signal line driving circuit 62 and the control line driving circuit 63 and controls the operation timings of the signal line driving circuit 62 and the control line driving circuit 63.

The signal line driving circuit 62 and the pixels 65 are connected by a plurality of signal lines Vs_{sig} provided along the column direction in FIG. 5. The control line driving circuit 63 and the respective pixels 65 are connected by a plurality of control lines CL provided along the row direction in FIG. 5. The signal line driving circuit 62 supplies signal voltages to the pixel portions 65 through the signal lines Vs_{sig}. The control line driving circuit 63 supplies scan line driving signals to the pixel portions 65 through the control lines CL.

FIG. 6A is a sectional view showing the interference filter 12 of the display device according to the first embodiment. The interference filter 12 is formed from a plurality of stacked dielectric films 121 to 133. The interference filter 12 is formed by stacking, for example, the silicon oxide films 121, 123 to 125, 127, 129 to 131, and 133 and the silicon nitride films 122, 126, 128, and 132.

The red interference filter 120R, the green interference filter 120G, and the blue interference filter 120B include a first common layer 141 (132 and 133), a second common layer 142 (126, 127, and 128), and a third common layer (also called a coating layer) 143 (121 and 122). The first common layer 141 is a film that continues through interference filters 120R, 120G, and 120B. The second common layer 142 is a film that continues through interference filters 120R, 120G, and 120B. The third common layer 143 is a film that continues through interference filters 120R, 120G, and 120B. The second common layer 142 faces the first common layer 141.

FIG. 6B is a plan view showing the first common layer 141. The first common layer 141 includes a first region 141R to form the red interference filter 120R, a second region 141G to form the green interference filter 120G, and a third region 141B to form the blue interference filter 120B.

A first spacer layer 151 is provided between the first common layer 141 and the second common layer 142. A second spacer layer 152 faces the first spacer layer 151 through the second common layer 142. The third common layer 143 overlaps the second spacer layer 152 in a direction in which the first common layer 141, the first spacer layer 151, and the second common layer 142 are stacked.

The red interference filter 120R includes a red first spacer layer (also called a first portion) 151R (129, 130, and 131) that is part of the first spacer layer 151 between the first common layer 141 and the second common layer 142. The red interference filter 120R also includes a red second spacer layer (also called a third portion) 152R (123, 124, and 125) that is part of the second spacer layer 152 between the second common layer 142 and the third common layer 143. The green interference filter 120G includes a green first spacer layer (also called a second portion) 151G (130 and 131) that is part of the first spacer layer 151 between the first common layer 141 and the second common layer 142. The green interference filter 120G also includes a green second spacer layer (also called a fourth portion) 152G (124 and 125) that is part of the second spacer layer 152 between the second common

layer 142 and the third common layer 143. The blue interference filter 120B includes a blue first spacer layer (also called a fifth portion) 151B (131) that is part of the first spacer layer 151 between the first common layer 141 and the second common layer 142. The blue interference filter 120B also includes a blue second spacer layer (also called a sixth portion) 152B (125) that is part of the second spacer layer 152 between the second common layer 142 and the third common layer 143.

The red first spacer layer 151R faces the first region 141R of the first common layer 141. The green first spacer layer 151G faces the second region 141G of the first common layer 141. The blue first spacer layer 151B faces the third region 141B of the first common layer 141. The red first spacer layer 151R, the green first spacer layer 151G, and the blue first spacer layer 151B have different thicknesses. The red first spacer layer 151R faces the red second spacer layer 152R. The green first spacer layer 151G faces the green second spacer layer 152G. The blue first spacer layer 151B faces the blue second spacer layer 152B. The red second spacer layer 152R, the green second spacer layer 152G, and the blue second spacer layer 152B have different thicknesses. Hence, the red interference filter 120R, the green interference filter 120G, and the blue interference filter 120B have different thicknesses.

In the present embodiment, the green first spacer layer 151G is thicker than the blue first spacer layer 151B, and the red first spacer layer 151R is thicker than the green first spacer layer 151G. In addition, the green second spacer layer 152G is thicker than the blue second spacer layer 152B, and the red second spacer layer 152R is thicker than the green second spacer layer 152G. Hence, the green interference filter 120G is thicker than the blue interference filter 120B, and the red interference filter 120R is thicker than the green interference filter 120G.

The interference filter 12 includes the second spacer layer and the third common layer in addition to the first common layer, the first spacer layer, and the second common layer, unlike the comparative example including the first common layer, the first spacer layer, and the second common layer. The first spacer layer 151 and the second spacer layer 152 are made of the same material. Note that the first spacer layer 151 and the second spacer layer 152 may be made of materials that are substantially identical but have slightly different composition ratios.

FIG. 7A is a table showing an example of the interference filter according to the first embodiment. FIG. 7B is a graph showing the light transmission characteristic of the interference filter. As shown in FIG. 7A, in the example of the interference filter 12, the third common layer 143 is formed from the 91.6-nm-thick silicon oxide film 121 and the 58.15-nm-thick silicon nitride film 122 that are stacked. The red second spacer layer 152R is formed from a 250.0-nm-thick silicon oxide film, the green second spacer layer 152G is formed from a 180.0-nm-thick silicon oxide film, and the blue second spacer layer 152B is formed from a 125.0-nm-thick silicon oxide film. The second common layer 142 is formed from the 58.15-nm-thick silicon nitride film 126, the 91.6-nm-thick silicon oxide film 127, and the 58.15-nm-thick silicon nitride film 128 that are stacked. The red first spacer layer 151R is formed from a 250.0-nm-thick silicon oxide film, the green first spacer layer 151G is formed from a 180.0-nm-thick silicon oxide film, and the blue first spacer layer 151B is formed from a 125.0-nm-thick silicon oxide film. The first common layer 141 is formed from the 58.15-nm-thick silicon nitride film 132 and the 91.6-nm-thick silicon oxide film 133 that are stacked.

Each of the common layers **141**, **142**, and **143** may be formed by stacking a plurality of dielectric films. In the present embodiment, the common layers **141**, **142**, and **143** are formed by stacking silicon nitride films and silicon oxide films. The first common layer **141**, the second common layer **142**, and the third common layer **143** can have the same thickness or different thicknesses. In the present embodiment, the first common layer **141** and the third common layer **143** have the same thickness. In interference filters **120R**, **120G**, and **120B** of all colors, the layers on the second common layer **142** and those under the second common layer **142** are symmetrical. Although the interference filter **12** is formed here by stacking the silicon oxide films and the silicon nitride films, dielectric films of another type may be used, or two or more kinds of dielectric films may be used. The thicknesses of the respective layers are not limited to those shown in FIG. 7A.

In FIG. 7B, the transverse axis represents the wavelength (unit: nm), and the vertical axis represents the transmittance of each interference filter shown in FIG. 7A. Each of interference filters **120R**, **120G**, and **120B** of the respective colors shown in this example has a wide spectral bandwidth representing the transmission region. Hence, the red interference filter **120R** transmits light in a wide wavelength region representing red. This also applies to the green interference filter **120G** and the blue interference filter **120B**. The transmittances of wavelength regions other than the transmission region are low, as compared to the light transmission characteristic of the comparative example shown in FIG. 2B. That is, in interference filters **120R**, **120G**, and **120B** of the respective colors, the colors mix little. If an interference filter transmits light of a color other than a desired color, for example, if the red interference filter **120R** transmits light of a color other than red as well, the light of the color other than red is absorbed by the absorption filter, resulting in a loss of light. On the other hand, if the transmittance of light of the color other than the desired color is low, as in the interference filter **12** of the present embodiment, the absorption filter **17** absorbs little light, resulting in little loss of light. That is, it is possible to obtain a display device that efficiently uses light from the backlight for display.

Alternatively, the display device may be provided with not the absorption filter but only the interference filter **12**. Even then, the display device can display an image of a desired color and the display color can be improved since the colors mix little in interference filters **120R**, **120G**, and **120B** of the respective colors.

When simulations are conducted using the interference filter shown in FIG. 7A, the ratio of efficiency to the conventional device is 1.65. The ratio of efficiency to the conventional device is a value representing the ratio of the efficiency of causing light emitted by the backlight to exit out of the liquid crystal panel when employing the display device according to the present embodiment to that when employing a display device without the interference filter. The upper limit of this value is 3 in principle. The larger the value is, the higher the efficiency is. On the other hand, when simulations are conducted using the interference filter shown in FIG. 3A, the ratio of efficiency to the conventional device is 1.40. The interference filter according to the present embodiment can efficiently transmit incident light and decrease the wavelength regions that cannot pass through the interference filter. For this reason, the loss of light is small.

FIG. 8 is a simulation chart showing the characteristics of the display device according to the first embodiment and the display device according to the comparative example. In FIG. 8, the transverse axis represents the recycle ratio that is the

ratio of light that is reflected by the interference filter, returned to the backlight, reflected by the reflecting plate, and returned to the interference filter, and the vertical axis represents the ratio of efficiency to the conventional device. The ratio of efficiency of the display device according to the first embodiment to the conventional device is higher than that of the display device according to the comparative example at any recycle ratio.

As described above, the interference filter **12** of the present embodiment can widen the transmission region and improve the light utilization of the display device.

Providing the absorption filter **17** in the display device is optional. A case in which the absorption filter **17** is provided in addition to the interference filter **12** will be explained here.

FIG. 9 shows an example of the transmission characteristic of the absorption filter **17**. In the absorption filter **17**, the spectra **171**, **172**, and **173** of the respective colors are wide but overlap in the regions of low transmittances, and the color reproducibility is undesirable. In the present embodiment, however, light passes through the interference filter **12** and then enters the absorption filter **17**. When the transmission spectrum of the absorption filter **17** is wider than that of the interference filter **12**, most light components that have passed through the interference filter **12** pass the absorption filter **17**. Out of the light that has passed through the interference filter **12**, light components in the wavelength regions of low transmittances are absorbed by the absorption filter **17**. For example, even when green light has passed through the red interference filter **120R**, the red absorption filter **171** absorbs the light.

In the interference filter **12** shown in FIGS. 7A and 7B, the NTSC ratio representing the color gamut is about 30%. The NTSC ratio is high when the transmittance difference between the transmission region and a wavelength region other than the transmission region is large out of the light that passes through the interference filter **12**. In the design of the interference filter **12**, when the transmission region is widened, the transmittances of the wavelength regions other than the transmission region may also rise. For example, when the transmittance of the red wavelength region is raised in the red interference filter **120R**, the transmittance in the green or blue wavelength region may also rise. In this case, the NTSC ratio becomes low.

On the other hand, the absorption filter **17** shown in FIG. 9 has an NTSC ratio of about 55%. When the interference filter **12** and the absorption filter **17** are used together, out of the light that has passed through the interference filter **12**, light components outside the transmission region are absorbed by the absorption filter **17**. Hence, the NTSC ratio can be improved. That is, when the interference filter **12** and the absorption filter **17** are used together, the interference filter **12** can prevent the loss of light of the backlight **40**, and the absorption filter **17** can improve the NTSC ratio.

The interference filter **12** transmits and reflects light using the interferential action of light based on the arrangement of the optical thin film group. When the light obliquely passes through the interference filter **12**, the optical path length is different from that when the light vertically passes through the interference filter **12**. Hence, the spectrum of the transmitted light shifts to the short wavelength side with respect to the spectrum of incident light in principle. That is, the color of the transmitted light may change between a case in which the interference filter **12** is observed from the front and a case in which the interference filter **12** is observed obliquely. However, in the present embodiment in which the interference filter **12** and the absorption filter **17** are used together, even when the light that has passed through the interference filter

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12 shifts to the short wavelength side, the absorption filter 17 absorbs the shifted light and thus suppresses the influence on the display color of the display device.

In addition, increasing the directivity of light emitted by the backlight 40 also enables to suppress the light that has passed through the interference filter from shifting to the short wavelength side. At this time, providing a light scattering member such as a light scattering plate in the liquid crystal panel 10 makes it possible to prevent the viewing angle from narrowing.

A method of manufacturing the interference filter according to the first embodiment will be described below. FIGS. 10A, 10B, 10C, 10D, 10E, 10F, 10G, 11A, 11B, 11C, 11D, and 11E are sectional views showing a method of manufacturing the interference filter of the display device shown in FIGS. 7A and 7B. First, the silicon oxide film 121 and the silicon nitride film 122 are formed on the support substrate 11 to form the third common layer 143. The silicon oxide film 123 is formed on the third common layer 143, as shown in FIG. 10A. A resist 134 is patterned by photolithography in a region of the silicon oxide film 123 where the red interference filter 120R is to be formed, as shown in FIG. 10B. The silicon oxide film 123 is patterned by chemical dry etching and left in the region where the red interference filter 120R is to be formed. After that, the resist 134 is removed, as shown in FIG. 10C.

The silicon oxide film 124 is formed, as shown in FIG. 10D. A resist 135 is patterned by photolithography, as shown in FIG. 10E. The silicon oxide film 124 is patterned by chemical dry etching and left in the regions where the red interference filter 120R and the green interference filter 120G are to be formed. After that, the resist 135 is removed, as shown in FIG. 10F. The silicon oxide film 125 is then formed.

Next, the silicon nitride film 126, the silicon oxide film 127, and the silicon nitride film 128 are formed to form the second common layer 142, as shown in FIG. 10G. The layer between the third common layer 143 and the second common layer 142 is the second spacer layer 152.

The silicon oxide film 129 is formed on the second common layer 142, as shown in FIG. 11A. The silicon oxide film 129 is patterned by performing chemical dry etching using a resist and left in the region where the red interference filter 120R is to be formed. After that, the resist is removed, as shown in FIG. 11B.

The silicon oxide film 130 is formed, as shown in FIG. 11C. The silicon oxide film 130 is patterned by performing chemical dry etching using a resist and left in the regions where the red interference filter 120R and the green interference filter 120G are to be formed. After that, the resist is removed, as shown in FIG. 11D. The silicon oxide film 131 is then formed.

The silicon nitride film 132 and the silicon oxide film 133 are formed to form the first common layer 141, as shown in FIG. 11E. The layer between the second common layer 142 and the first common layer 141 is the first spacer layer 151.

These silicon nitride films and silicon oxide films can be formed by, for example, chemical vapor deposition (CVD) or sputtering.

FIG. 12 is a flowchart showing a method of manufacturing the display device according to the first embodiment.

The display device manufacturing method includes step S310 of forming a liquid crystal panel, step S320 of forming a backlight, and step S330 of combining the liquid crystal panel and the backlight. Step S310 of forming the liquid crystal panel includes step S311 of preparing a support substrate, step S312 of forming an interference filter, step S313 of forming pixel driving transistors and pixel electrodes, step S314 of forming an absorption filter, step S315 of forming a liquid crystal layer, and step S316 of forming a counterelectrode.

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In the arrangement of the interference filter 12 according to the present embodiment, each silicon oxide film may be replaced with a silicon nitride film, and each silicon nitride film may be replaced with a silicon oxide film. Adjusting the thickness of each film allows the red interference filter 120R to transmit red light, the green interference filter 120G to transmit green light, and the blue interference filter 120B to transmit blue light.

The arrangement of the interference filter 12 according to the present embodiment can be observed along its section when the liquid crystal panel is cut in a direction perpendicular to the support substrate 11. For example, this section can be observed using a scanning transmission electron microscope (STEM).

Note that in the present embodiment, when the first common layer 141, the second common layer 142, and the third common layer 143 have the same thickness, the transmittance near the center of the transmission region may be low. That is, the transmission spectrum may have two maximum values (peaks) in the transmission region. To prevent this, the first common layer 141 and the third common layer 143 are preferably made thinner than the second common layer 142.

Second Embodiment

FIG. 13A is a table showing an example of an interference filter according to the second embodiment. FIG. 13B is a graph showing the light transmission characteristic of the interference filter shown in FIG. 13A. The transverse axis represents the wavelength (unit: nm) of light that passes through the interference filter, and the vertical axis represents a transmittance T.

In an interference filter 121 according to the present embodiment, a red interference filter 121R and a blue interference filter 121B include neither a third common layer 143 nor a second spacer layer 152. That is, only a green interference filter 121G includes the third common layer 143 and the second spacer layer 152. A second common layer 142, a first spacer layer 151, and a first common layer 141 are formed so as to cover the third common layer 143 and the second spacer layer 152.

The first common layer 141 and the second common layer 142 face each other. As in the first embodiment, the first common layer 141 includes a first region 141R, a second region 141G, and a third region 141B.

The first spacer layer 151 is provided between the first common layer 141 and the second common layer 142. A red first spacer layer 151R faces the first region 141R of the first common layer 141. A green first spacer layer 151G faces the second region 141G of the first common layer 141. A blue first spacer layer 151B faces the third region 141B of the first common layer 141. The red first spacer layer 151R, the green first spacer layer 151G, and the blue first spacer layer 151B have different thicknesses. The green first spacer layer 151G faces a green second spacer layer 152 through the second common layer 142. The third common layer 143 faces the second common layer 142 through the second spacer layer 152. Hence, the red interference filter 121R, the green interference filter 121G, and the blue interference filter 121B have different thicknesses. The second common layer 142 is continuously provided so as to face the red first spacer layer 151R, the green first spacer layer 151G, and the blue first spacer layer 151B.

In the present embodiment, the blue first spacer layer 151B is thicker than the red first spacer layer 151R, and the green first spacer layer 151G is thicker than the blue first spacer layer 151B. Hence, the blue interference filter 121B is thicker than the red interference filter 121R, and the green interference filter 121G is thicker than the blue interference filter 121B.

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More specifically, the third common layer **143** is provided on a support substrate (not shown). The third common layer **143** includes a silicon nitride film **161** and a silicon oxide film **162**. The second spacer layer **152** is provided on the third common layer **143** and formed from a silicon nitride film. The second common layer **142** is provided on the second spacer layer **152** and the support substrate, and includes a silicon nitride film **163**, a silicon oxide film **164**, a silicon nitride film **165**, and a silicon oxide film **166**. The first spacer layer **151** is provided on the second common layer **142** and formed from a silicon nitride film. The first common layer **141** is provided on the first spacer layer, and includes a silicon oxide film **167**, a silicon nitride film **168**, and a silicon oxide film **169**. The films have thicknesses as shown in FIG. 13A.

Each of the red interference filter **121R** and the blue interference filter **121B** is formed from the first common layer **141**, the second common layer **142**, and the first spacer layer **151** provided between them, like the interference filter **200** according to the comparative example shown in FIG. 1. On the other hand, the green interference filter **121G** includes the first common layer **141**, the second common layer **142**, and the third common layer **143**, and the first spacer layer **151** provided between the first common layer **141** the second common layer **142**, and the second spacer layer **152** provided between the second common layer **142** and the third common layer **143**, like the interference filter **12** according to the first embodiment.

In the present embodiment, both the second spacer layer **152** and a layer (silicon nitride film **163**) out of the second common layer **142**, which is in contact with the second spacer layer **152**, are formed from silicon nitride films. A portion (silicon nitride film **163**) having the same thickness in interference filters **121R**, **121G**, and **121B** of the respective colors is the second common layer **142**, and the remaining portion (silicon nitride film **152**) is the second spacer layer **152**.

Out of red, green, and blue, the wavelength region of green is located at the center. Hence, when the wavelength region of light that passes through the green interference filter **121G** is widened, the amount of light that passes through the interference filter can be increased, and wavelength regions that do not pass through the interference filter can be reduced.

When simulations are conducted for the interference filter **121** shown in FIG. 13A, the ratio of efficiency to the conventional device is 1.55. In the second embodiment as well, the amount of light that passes through the interference filter can advantageously be increased, as compared to the comparative example, and wavelength regions that do not pass through the interference filter can be reduced.

According to the present embodiment as well, it is possible to obtain an interference filter having a wide transmission region and little loss of light.

The interference filter of the present embodiment can also be used in a display device, like the interference filter of the first embodiment.

In the present embodiment, only the green interference filter **121G** is provided with the third common layer **143** and the second spacer layer **152**. However, for example, only the red interference filter **121R**, only the blue interference filter **121B**, or the interference filters of arbitrary two colors may be provided with the third common layer **143** and the second spacer layer **152**.

Third Embodiment

FIG. 14A is a table showing an example of an interference filter **122** according to the third embodiment. FIG. 14B is a graph showing the light transmission characteristic of the

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interference filter **122** shown in FIG. 14A. The transverse axis represents the wavelength (unit: nm) of light that passes through the interference filter, and the vertical axis represents a transmittance *T*.

In an interference filter **122** according to the present embodiment, a red interference filter **122R** and a blue interference filter **122B** include neither a third common layer **143** nor a second spacer layer **152**. That is, only a green interference filter **122G** includes the third common layer **143** and the second spacer layer **152**. A first common layer **141** is provided on a support substrate (not shown).

The first common layer **141** and a second common layer **142** face each other. As in the first embodiment, the first common layer **141** includes a first region **141R**, a second region **141G**, and a third region **141B**. A first spacer layer **151** is provided between the first common layer **141** and the second common layer **142**. A red first spacer layer **151R** faces the first region **141R** of the first common layer **141**. A green first spacer layer **151G** faces the second region **141G** of the first common layer **141**. A blue first spacer layer **151B** faces the third region **141B** of the first common layer **141**. The red first spacer layer **151R**, the green first spacer layer **151G**, and the blue first spacer layer **151B** have different thicknesses. The green first spacer layer **151G** faces a second spacer layer **152** through the second common layer **142**. The third common layer **143** faces the second common layer **142** through the second spacer layer **152**. Hence, the red interference filter **122R**, the green interference filter **122G**, and the blue interference filter **122B** have different thicknesses. The second common layer is continuously provided so as to facing the red first spacer layer **151R**, the green first spacer layer **151G**, and the blue first spacer layer **151B**.

In the present embodiment, the blue first spacer layer **151B** is thicker than the red first spacer layer **151R**, and the green first spacer layer **151G** is thicker than the blue first spacer layer **151B**. Hence, the blue interference filter **122B** is thicker than the red interference filter **122R**, and the green interference filter **122G** is thicker than the blue interference filter **122B**.

More specifically, the first common layer **141** is provided on the support substrate (not shown). The first common layer **141** includes a silicon oxide film **171**, a silicon nitride film **172**, and a silicon oxide film **173**. The first spacer layer **151** is provided on the first common layer **141** and formed from a silicon nitride film. The second common layer **142** is provided on the first spacer layer **151**, and includes a silicon oxide film **174**, a silicon nitride film **175**, a silicon oxide film **176**, and a silicon nitride film **177**. The second spacer layer **152** is provided on the second common layer **142** and formed from a silicon nitride film. The third common layer **143** is provided on the second spacer layer **152**, and includes a silicon oxide film **178**, a silicon nitride film **179**, and a silicon oxide film **180**. The films have thicknesses as shown in FIG. 14A.

Each of the red interference filter **122R** and the blue interference filter **122B** is formed from the first common layer **141**, the second common layer **142**, and the first spacer layer **151** provided between them, like the interference filter **200** according to the comparative example shown in FIG. 1. On the other hand, the green interference filter **122G** includes the first common layer **141**, the second common layer **142**, and the third common layer **143**, the first spacer layer **151** provided between the first common layer **141** and the second common layer **142**, and the second spacer layer **152** provided between the second common layer **142** and the third common layer **143**, like the interference filter **12** according to the first embodiment.

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In the present embodiment, both the second spacer layer **152** and a layer (silicon nitride film **177**) out of the second common layer **142**, which is in contact with the second spacer layer **152**, are formed from silicon nitride films. Out of the silicon nitride films, a portion (silicon nitride film **177**) having the same thickness in the interference filters **122R**, **122G**, and **122B** of the respective colors is the second common layer **142**, and the remaining portion (silicon nitride film **151**) is the first spacer layer **151**.

Out of red, green, and blue, the wavelength region of green is located at the center. Hence, when the wavelength region of light that passes through the green interference filter **122G** is widened, the amount of light that passes through the interference filter can be increased, and wavelength regions of light that do not pass through the interference filter can be reduced.

When simulations are conducted for the interference filter **122** shown in FIG. **14A**, the ratio of efficiency to the conventional device is 1.64. In the third embodiment as well, the amount of light that passes through the interference filter can advantageously be increased, as compared to the comparative example, and wavelength regions that do not pass through the interference filter can be reduced.

According to the present embodiment as well, it is possible to obtain an interference filter having a wide transmission region and little loss of light.

The interference filter of the present embodiment can also be used in a display device, like the interference filter of the first embodiment.

In the present embodiment, only the green interference filter **122G** is provided with the third common layer **143** and the second spacer layer **152**. However, for example, only the red interference filter **122R**, only the blue interference filter **122B**, or the interference filters of arbitrary two colors may be provided with the third common layer **143** and the second spacer layer **152**.

According to at least one embodiment described above, there are provided an interference filter having a wide transmission region, a display device including the interference filter, and method of manufacturing the display device.

The embodiments are described above with reference to detailed examples. However, the embodiments are not limited to those detailed examples. For example, detailed arrangements of elements such as a light guide plate, a prism row portion, a prism member, a high-refractive-index layer, a low-refractive-index layer, and a deflecting portion included in the light guide member, and a light source included in a surface light source are incorporated in the embodiment as far as those skilled in the art can similarly practice the embodiment and obtain the same effects as described above by appropriately selecting the elements from a known scope.

In addition, a combination of two or more detailed examples within the technical scope is also incorporated in the embodiment as far as it incorporates the gist of the embodiment.

All light guide members and surface light sources those skilled in the art can practice by changing the designs of the light guide member and the surface light source described as the embodiments are also incorporated in the embodiment as far as they incorporate the gist of the embodiment.

In addition, those skilled in the art can anticipate various changes and modifications within the ideological scope of the embodiment, and the changes and modifications are also incorporated in the embodiment.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be

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embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. A display device, comprising:

an interference filter comprising:

a first common layer comprising a first region, a second region, and a third region;

a second common layer facing the first common layer;

a first spacer layer provided between the first common layer and the second common layer and comprising a first portion facing the first region, a second portion facing the second region, and a third portion facing the third region, the first portion having a first thickness, the second portion having a second thickness different from the first thickness, the third portion having a third thickness different from the first thickness and the second thickness;

a second spacer layer comprising a fourth portion facing the first portion through the second common layer, a fifth portion facing the second portion through the second common layer, and a sixth portion facing the third portion through the second common layer, the second spacer layer being made of a same material as a material of the first spacer layer;

a coating layer comprising a seventh portion facing the fourth portion, an eighth portion facing the fifth portion, and a ninth portion facing the sixth portion; and

a display layer facing the interference filter,

wherein:

each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film; and

one or two of the following conditions is satisfied:

a total thickness of the fourth portion and the seventh portion is zero;

a total thickness of the fifth portion and the eighth portion is zero; and

a total thickness of the sixth portion and the ninth portion is zero.

2. The device according to claim 1, wherein the second common layer is continuously provided to face the first portion, the second portion, and the third portion.

3. The device according to claim 1, wherein the first thickness is greater than the second thickness.

4. The device according to claim 1, wherein the first thickness is greater than the third thickness.

5. The device according to claim 1, wherein:

the interference filter comprises a first interference filter portion including the first region of the first common layer, a second interference filter portion including the second region of the first common layer, and a third interference filter portion including the third region of the first common layer;

the first interference filter portion is configured to transmit light in a first wavelength region and to reflect light in a wavelength region other than the first wavelength;

the second interference filter portion is configured to transmit light in a second wavelength region different from the first wavelength region and to reflect light in a wavelength region other than the second wavelength region; and

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the third interference filter portion is configured to transmit light in a third wavelength region different from the first wavelength region and the second wavelength region and to reflect light in a wavelength region other than the third wavelength region.

6. The device according to claim 1, wherein a portion where one of
the total thickness of the fourth portion and the seventh portion,
the total thickness of the fifth portion and the eighth portion, and
the total thickness of the sixth portion and the ninth portion, is not zero, transmits green light.

7. The device according to claim 1, further comprising an absorption filter facing the interference filter through the display layer.

8. The device according to claim 1, wherein the display layer is a liquid crystal layer.

9. An interference filter, comprising:

a first common layer comprising a first region, a second region, and a third region;

a second common layer facing the first common layer;

a first spacer layer provided between the first common layer and the second common layer and comprising a first portion facing the first region, a second portion facing the second region, and a third portion facing the third region, the first portion having a first thickness, the second portion having a second thickness different from the first thickness, the third portion having a third thickness different from the first thickness and the second thickness;

a second spacer layer comprising a fourth portion facing the first portion through the second common layer, a fifth portion facing the second portion through the second common layer, and a sixth portion facing the third portion through the second common layer, the second spacer layer being made of a same material as a material of the first spacer layer; and

a coating layer comprising a seventh portion facing the fourth portion, an eighth portion facing the fifth portion, and a ninth portion facing the sixth portion,

wherein:

each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film; and

one or two of the following conditions is satisfied:

a total thickness of the fourth portion and the seventh portion is zero;

a total thickness of the fifth portion and the eighth portion is zero; and

a total thickness of the sixth portion and the ninth portion is zero.

10. The interference filter according to claim 9, wherein the second common layer is continuously provided to face the first portion, the second portion, and the third portion.

11. The interference filter according to claim 9, wherein the first thickness is greater than the second thickness.

12. The interference filter according to claim 9, wherein the first thickness is greater than the third thickness.

13. The interference filter according to claim 9, comprising a first interference filter portion including the first region of the first common layer, a second interference filter portion

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including the second region of the first common layer, and a third interference filter portion including the third region of the first common layer,

wherein:

the first interference filter portion is configured to transmit light in a first wavelength region and to reflect light in a wavelength region other than the first wavelength;

the second interference filter portion is configured to transmit light in a second wavelength region different from the first wavelength region and to reflect light in a wavelength region other than the second wavelength region; and

the third interference filter portion is configured to transmit light in a third wavelength region different from the first wavelength region and the second wavelength region and to reflect light in a wavelength region other than the third wavelength region.

14. The interference filter according to claim 9, wherein a portion where one of

the total thickness of the fourth portion and the seventh portion,

the total thickness of the fifth portion and the eighth portion, and

the total thickness of the sixth portion and the ninth portion, is not zero, transmits green light.

15. A display device manufacturing method, comprising: forming an interference filter, the interference filter comprising:

a first common layer comprising a first region, a second region, and a third region;

a second common layer facing the first common layer;

a first spacer layer provided between the first common layer and the second common layer and comprising a first portion facing the first region, a second portion facing the second region, and a third portion facing the third region, the first portion having a first thickness, the second portion having a second thickness different from the first thickness, the third portion having a third thickness different from the first thickness and the second thickness;

a second spacer layer comprising a fourth portion facing the first portion through the second common layer, a fifth portion facing the second portion through the second common layer, and a sixth portion facing the third portion through the second common layer, the second spacer layer being made of a same material as a material of the first spacer layer; and

a coating layer comprising a seventh portion facing the fourth portion, an eighth portion facing the fifth portion, and a ninth portion facing the sixth portion,

wherein:

each of the first common layer, the first spacer layer, the second common layer, the second spacer layer, and the coating layer is formed from a dielectric film; and one or two of the following conditions is satisfied:

a total thickness of the fourth portion and the seventh portion is zero;

a total thickness of the fifth portion and the eighth portion is zero; and

a total thickness of the sixth portion and the ninth portion is zero; and

forming a display layer facing the interference filter.

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